Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Use of the 5.850-5.925 GHz Band	)	ET Docket No. 19-138

ORDER ON RECONSIDERATION

Adopted: March 15, 2024 **Released: March 18, 2024**

By the Commission:

I. INTRODUCTION

1. In this Order on Reconsideration, we reject a Petition for Reconsideration and a Petition for Partial Reconsideration of the *First Report and Order*[1] in this proceeding filed by the Alliance for Automotive Innovation (Auto Innovators)[2] and the 5G Automotive Association (5GAA),[3] respectively. In the *First Report and Order*, the Commission repurposed the 5.850-5.895 GHz portion of the 5.850-5.925 GHz (5.9 GHz) band (lower 45 megahertz) from intelligent transportation system (ITS) use[4] to provide more flexible unlicensed use,[5] while continuing to dedicate the 5.895-5.925 GHz portion of the 5.9 GHz band (upper 30 megahertz) for vital ITS applications.[6] It also adopted technical and operating rules to minimize the potential for unlicensed operations in the lower 45 megahertz to cause harmful interference[7] to incumbent 5.9 GHz band services—including federal incumbents and ITS operations.[8] Auto Innovators, through its petition, seeks reconsideration of the Commission's decision to redesignate

[1] *Use of the 5.850-5.925 GHz Band*, ET Docket No. 19-138, First Report and Order (*First Report and Order*), Further Notice of Proposed Rulemaking (*FNPRM*), and Order of Proposed Modification, 35 FCC Rcd 13440 (2020), *corrected by* Erratum (OET Dec. 11, 2020) and Second Erratum, 36 FCC Rcd 1444 (OET 2021), *aff'd* Intelligent Transportation Society of America v. FCC, 45 F.4th 406 (D.C. Cir. 2022) (*ITS America v. FCC*). The *FNPRM* remains pending.

[2] Petition for Reconsideration of the Alliance for Automotive Innovation, ET Docket No. 19-138 (filed June 2, 2021) (Auto Innovators Petition).

[3] Petition for Partial Reconsideration of the 5G Automotive Association, ET Docket No. 19-138 (filed June 2, 2021) (5GAA Petition).

[4] ITS is a national program intended to improve the efficiency and safety of surface transportation systems. *See* Intermodal Surface Transportation Efficiency Act of 1991, Pub. L. No. 102-240, § 6051, 105 Stat. 1914 (1991).

[5] Unlicensed devices are authorized under part 15 of the Commission's rules and operate on the conditions of not causing harmful interference and accepting any interference from an authorized radio station. 47 CFR § 15.5(b)-(c). Radio frequency devices authorized pursuant to 47 CFR part 15 are not based on allocated radio services. 47 CFR § 2.105(e) note 1.

[6] *First Report and Order*, 35 FCC Rcd at 13446, para. 14.

[7] Under the Commission's rules, harmful interference is defined as "[i]nterference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with [the ITU] Radio Regulations." 47 CFR § 2.1(c).

[8] *First Report and Order*, 35 FCC Rcd at 13468-69, paras. 65-67; 13475-77, paras. 83, 85. 47 CFR § 15.407(a)(3)(ii)-(v), (b)(5)(i)-(iii), (e).

the lower 45 megahertz for unlicensed use.[9] 5GAA, through its petition, seeks reconsideration of the unlicensed device out-of-band emissions (OOBE) limits into the upper 30 megahertz retained for ITS operations.[10] For the reasons discussed below, we deny the petitions and affirm the Commission's decision to repurpose spectrum previously designated for ITS services to provide more flexibility for unlicensed device uses to help meet the burgeoning demand for wireless broadband in the United States.

II. BACKGROUND

2. In 1999, in consultation with the Department of Transportation (DOT), the Commission designated 75 megahertz of spectrum in the 5.9 GHz band for Dedicated Short Range Communications (DSRC) systems in the ITS radio service, setting forth the rules and protocols for the radio systems designed to enable transportation and vehicle safety-related communications.[11] A subsequent order in 2003 established licensing and service rules for DSRC operations.[12] Under the adopted service rules, DSRC licensees shared the 5.9 GHz band with several other services, including amateur radio service and fixed-satellite service (for uplinks) as well as with federal radiolocation service (radar) systems.[13] When the Commission designated the 5.9 GHz band for ITS, it was expected that the band would support widespread deployment of systems that would improve efficiency and promote safety within the nation's transportation infrastructure.[14] However, in the time since the Commission designated the 5.9 GHz band for ITS service, DSRC deployment was minimal. Many automotive safety functions originally contemplated for the 5.9 GHz band over 20 years ago—such as alerting drivers to vehicles or other objects, lane-merging alerts, and emergency braking—are being met in other spectrum bands (e.g., 76-81 GHz[15]) or by other technologies like radar, light detection and ranging (LiDAR), cameras, and other sensors.[16]

3. Given the technological shift for delivering automotive safety functions and the public interest benefits that would be gained by repurposing spectrum lying fallow, the Commission adopted the *First Report and Order*, wherein it removed the lower 45 megahertz from ITS use and adopted rules

[9] Auto Innovators Petition at 1.

[10] 5GAA Petition at 2.

[11] *Amendment of Parts 2 and 90 of the Commission's Rules to Allocate the 5.850-5.925 GHz Band to the Mobile Service for Dedicated Short Range Communications of Intelligent Transportation Services*, ET Docket No. 98-95, Report and Order, 14 FCC Rcd 18221 (1999) (*DSRC Report and Order*); 47 CFR § 90.371(a) (2020 Edition). In the 1998 Transportation Equity Act for the 21st Century (Transportation Equity Act or TEA), Pub. L. No. 105-178, 112 Stat. 107, Congress instructed the Commission to "consider, in consultation with the Secretary [of Transportation], spectrum needs for the operation of intelligent transportation systems" by January 1, 2000. 23 U.S.C. § 502 note § 5206(f); Congress instructed the DOT to "develop and maintain a national" intelligent transportation system to decrease accidents and improve overall travel efficiency. 23 U.S.C. § 517(a)(1).

[12] *Amendment of the Commission's Rules Regarding Dedicated Short Range Communications Services in the 5.850-5.925 GHz Band (5.9 GHz Band)*, WT Docket No. 01-90*; Amendment of Parts 2 and 90 of the Commission's Rules to Allocate the 5.850-5.925 GHz Band to the Mobile Service for Dedicated Short Range Communications of Intelligent Transportation Services*, ET Docket No. 98-95, Report and Order, ET Docket No. 98-95, 19 FCC Rcd 2458, 2466-68, paras. 13-16 (2003) (*DSRC Service Rules Order*).

[13] 47 CFR § 2.106.

[14] *DSRC Report and Order*, 14 FCC Rcd at 18225, para. 9 (designating the 5.9 GHz band for DSRC based on a finding that "DSRC applications are a key element in meeting the nation's transportation needs into the next century and in improving the safety of our nation's highways").

[15] *See First Report and Order*, 35 FCC Rcd at 13456, para. 38 & n.103 (citing *Amendment of Parts 1, 2, 15, 90 and 95 of the Commission's Rules to Permit Radar Services in the 76-81 GHz Band*, ET Docket No. 15-26, Report and Order, 32 FCC Rcd 8822 (2017)).

[16] *First Report and Order*, 35 FCC Rcd at 13456-57, para. 38.

expanding unlicensed national information infrastructure (U-NII) operations[17] such as Wi-Fi into that spectrum.[18] The Commission made this decision partially because the DSRC services once contemplated for the 5.9 GHz band had not come to fruition in the 20 years since it allocated the spectrum for the ITS service. It concluded that rather than reserving the entire 75 megahertz of the 5.9 GHz band for vehicle-safety features that can be or are already being provided using other spectrum bands or alternative technology, 30 megahertz would be sufficient for ITS licensees to effectively use the spectrum for vehicle safety-related applications.[19] The Commission found unconvincing claims about future plans for advanced DSRC-based ITS services and indicated that the future ITS services were too uncertain or remote to justify retaining the full 75 megahertz of the 5.9 GHz for ITS.[20] Accordingly, the Commission concluded that reserving the entire 5.9 GHz band for possible additional ITS services would not be the most efficient or effective use of that band, nor in the public interest to continue to do so.[21]

4. The Commission determined that its action modifying all existing ITS authorizations to transition such operations to only the upper 30 megahertz was well within the Commission's statutory authority under section 316 of the Communications Act of 1934, as amended, consistent with prior Commission practice, and furthers the promotion of the public interest, convenience, and necessity.[22] The Commission found that this modification was manifestly in the public interest because it would make room for additional valuable unlicensed use in the lower 45 megahertz of the band, while allowing existing ITS operations sufficient spectrum to continue to provide substantially the same basic vehicular safety services.[23] The Commission also found that its decision to repurpose the lower 45 megahertz to provide more flexible unlicensed use was not in conflict with any role assigned to it by Congress.[24]

5. In making the lower 45 megahertz available for more flexible unlicensed use, the Commission found that, when added to U-NII spectrum in the adjacent 5.725-5.850 GHz (denoted as U-NII-3) band, the 45 megahertz of spectrum from the 5.850-5.895 GHz (denoted as U-NII-4) band would provide for increased high-throughput broadband applications in spectrum that is a core component of today's unlicensed ecosystem, thereby providing the American public with the most efficient and effective use of this valuable mid-band spectrum.[25] At the same time, the Commission recognized the

---

[17] Unlicensed national information infrastructure (U-NII) devices are intentional radiators operating in mid-band spectrum that use wideband digital modulation techniques and provide a wide array of high data rate mobile and fixed communications for individuals, businesses, and institutions. 47 CFR § 15.403 Definitions. U-NII devices operate in the 5 GHz and 6 GHz spectrum bands, part of the larger mid-band spectrum (a designation generally applied to spectrum between 2.5 GHz and 24 GHz). Mid-band spectrum has become highly desirable as a key component for future 5G buildout because of its balanced coverage and capacity characteristics. *See, e.g.*, The FCC's 5G FAST Plan (Sept. 28, 2018), https://www.fcc.gov/document/fccs-5g-fast-plan.

[18] *First Report and Order*, 35 FCC Rcd at 13449, para. 20. Wi-Fi is a family of wireless network protocols, based on the IEEE 802.11 set of standards, which are commonly used for local area networking of devices and Internet access. Wi-Fi has become indispensable for providing low-cost wireless connectivity in countless products used by American consumers. *Id.* at 13441 & n.2. Mobile operators routinely use spectrum on an unlicensed basis for network offloading and mobile carriers have widely implemented Wi-Fi calling. *Id.* at 13446-47, paras. 15-16.

[19] *First Report and Order*, 35 FCC Rcd at 13456, paras. 36-37.

[20] *Id*. at 13488, para. 120.

[21] *Id*. at 13451, para. 27.

[22] *Id*. at 13463, para. 52 (citing 47 U.S.C. § 316).

[23] *Id*. at 13486-87, para. 117.

[24] *Id*. at 13489-90, paras. 123-124. In the TEA, Congress instructed the DOT to "develop and maintain a national" intelligent transportation system to decrease accidents and improve overall travel efficiency. 23 U.S.C. § 517(a)(1); Congress instructed the Commission to "consider, in consultation with the Secretary [of Transportation], spectrum needs for the operation of intelligent transportation systems" by January 1, 2000. 23 U.S.C. § 502 note § 5206(f).

[25] *First Report and Order*, 35 FCC Rcd at 13441, para. 2; 13446, para. 14; 13449, para. 20.

importance of maintaining some spectrum to support ITS applications, even though DSRC had sparsely been deployed and failed to become ubiquitously used for the broad range of traffic safety applications that were originally anticipated in the 5.9 GHz band.[26] The Commission designated the upper 30 megahertz to improve automotive safety through ITS applications, and required that, within one year of the effective date of the *First Report and Order*, ITS licensees must cease operations on channels in the lower 45 megahertz and move to channels in the upper 30 megahertz.[27] To help enhance the roll-out of ITS services and promote the most efficient and effective use of this ITS spectrum, the Commission updated the associated service rules for vehicular communications in the upper 30 megahertz to transition from the original DSRC protocol adopted in 1999 to a wireless technology-based protocol known as Cellular Vehicle To Everything (C-V2X),[28] at the end of a transition period to be determined through the record generated by the *FNPRM* in this proceeding.[29]

6. To protect incumbent 5.9 GHz band services, including federal incumbents and ITS operations, from potential harmful interference by unlicensed operations, the Commission imposed stringent power limits and operating requirements on unlicensed devices (i.e., access points, subordinate devices, and client devices) operating in the lower 45 megahertz, restricting unlicensed use of the lower 45 megahertz to indoor locations.[30] In addition, to protect the ITS operations during and after their transition to the upper 30 megahertz, the Commission set OOBE limits allowed in the upper 30 megahertz for indoor unlicensed operations in the lower 45 megahertz based on, but not identical to, the previously-affirmed OOBE limits for unlicensed operations in the 5.725-5.850 GHz (U-NII-3) band.[31] Since the Commission restricted unlicensed use of the lower 45 megahertz to indoor use only, the Commission took advantage of building attenuation, as well as other factors such as path loss, to increase the OOBE limits allowed in the upper 30 megahertz from the indoor unlicensed operations by an additional 20 dB as

[26] *Id*. at 13441-42, para. 3, 13443, para. 7; 13451, paras. 26-28.

[27] *Id*. at 13462, para. 49, 13484-85, para. 110.

[28] C-V2X standards development began in 2015 when the 3rd Generation Partnership Project (3GPP) specified C-V2X features based on the 4G LTE-Pro system in 3GPP Release 14. Recently, C-V2X-based technology has gained momentum as a means of providing transportation and vehicle safety-related communications. *First Report and Order*, 35 FCC Rcd at 13443-44, para. 8 & nn.11, 14.

[29] *First Report and Order*, 35 FCC Rcd at 13479, para. 95; *FNPRM*, 35 FCC Rcd at 13500-08, paras. 146-168.

[30] *First Report and Order*, 35 FCC Rcd at 13466-76, paras. 61-79. 47 CFR § 15.407(a)(3)(ii)-(v). A U-NII access point operates either as a bridge in a peer-to-peer connection or as a connector between the wired and wireless segments of the network, or as a relay between wireless network segments. A U-NII subordinate device operates in the 5.850-5.895 GHz or in the 5.925-7.125 GHz band under the control of an indoor access point. A U-NII client device transmits generally under the control of an access point and is not capable of initiating a network. An indoor access point or subordinate device is supplied power from the wired connection, has an integrated antenna, is not battery powered, and does not have a weatherized enclosure. Access points that operate in the 5.850-5.895 GHz band are restricted to indoor use; subordinate devices and client devices that operate in the 5.850-5.895 GHz band must operate under the control of an indoor access point. 47 CFR §§ 15.403, 15.407(a)(3)(ii)-(v). In the *FNPRM* in this proceeding, there are pending proposals to establish rules permitting outdoor use of unlicensed devices in the 5.850-5.895 GHz band. *See FNPRM*, 35 FCC Rcd at 13508-14, paras. 169-185.

[31] *See First Report and Order*, 35 FCC Rcd at 13475-76, para. 83 (citing *Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*, First Report and Order, 29 FCC Rcd 4127 (2014), *recon. denied,* Memorandum Opinion and Order, 31 FCC Rcd 2317 (2016) (*U-NII 5 GHz MO&O*)). Under the Commission's current rules, out-of-band emissions from unlicensed transmitters operating in the 5.725-5.850 GHz (U-NII-3) band are limited to -27 dBm/MHz at 75 megahertz or more above or below the band edge increasing linearly to 10 dBm/MHz at 25 megahertz above or below the band edge, and from 25 megahertz above or below the band edge increasing linearly to 15.6 dBm/MHz at 5 megahertz above or below the band edge, and from 5 megahertz above or below the band edge increasing linearly to 27 dBm/MHz at the band edge. 47 CFR § 15.407(b)(4)(i). These specifications result in OOBE limits of -5 dBm/MHz at 5.895 GHz, decreasing linearly to -27 dBm/MHz at 5.925 GHz.

compared to the 5.725-5.850 GHz (U-NII-3) band OOBE limits.[32] The Commission found these OOBE limits from indoor unlicensed operations mirror the OOBE limits for unlicensed operations in the 5.725-5.850 GHz (U-NII-3) band after accounting for building attenuation.[33] The Commission also permitted a root mean square (RMS) detector, instead of requiring a peak detector, to be used to conduct all 5.9 GHz band unlicensed device OOBE measurements. The Commission found that RMS measurement is more appropriate for ensuring that the potential for U-NII devices to cause harmful interference to adjacent-band operations is minimized because RMS measurements represent the continuous power being generated from a device, as opposed to peak power, which may only be reached occasionally and for short periods of time.[34]

7. *Petitions*. In response to the *First Report and Order*, Auto Innovators and 5GAA filed petitions for reconsideration on June 2, 2021.[35] In its Petition for Reconsideration, Auto Innovators asks the Commission to reconsider its designation of the lower 45 megahertz for unlicensed uses and restore that portion of the 5.9 GHz band for ITS.[36] In its Petition for Partial Reconsideration, 5GAA asks the Commission to reduce the OOBE limits permitted in the upper 30 megahertz designated for ITS services from indoor unlicensed access points, subordinate devices, and client devices operating in the lower 45 megahertz.[37] Notice of the filing of the petitions was published in the Federal Register on July 7, 2021.[38]

8. *ITS America v. FCC*. While the reconsideration process remained pending, the Intelligent Transportation Society of America (ITS America) and the American Association of State Highway and Transportation Officials (AASHTO) petitioned the United States Court of Appeals for the D.C. Circuit to vacate the part of the *First Report and Order* repurposing the lower 45 megahertz for unlicensed operations.[39] The Amateur Radio Emergency Data Network (AREDN) filed a separate petition asking the court to vacate the entire *First Report and Order*.[40] As discussed below, many of the arguments presented by the reconsiderations petitioners overlap with the court petitioners' arguments. The D.C. Circuit

[32] Specifically, for indoor unlicensed access point or subordinate devices operating solely in the 5.850-5.895 GHz (U-NII-4) band or on a channel that spans across 5.725-5.895 GHz (U-NIII-3 and U-NII-4), all emissions at or above 5.895 GHz must not exceed an equivalent isotropically radiated power (EIRP) of 15 dBm/MHz at 5.895 GHz, decreasing linearly to 7 dBm/MHz at or above 5.925 GHz. *First Report and Order*, 35 FCC Rcd at 13475-76, para. 83; 47 CFR § 15.407(b)(5)(i). For client devices operating solely in the 5.850-5.895 GHz (U-NII-4) band or on a channel that spans across 5.725-5.895 GHz (U-NIII-3 and U-NII-4), all emissions at or above 5.895 GHz must not exceed an EIRP of -5 dBm/MHz and decrease linearly to an EIRP of -27 dBm/MHz at or above 5.925 GHz. 47 CFR § 15.407(b)(5)(ii).

[33] *First Report and Order*, 35 FCC Rcd at 13475-76, para. 83.

[34] *Id*. at 13476-77, paras. 84-85.

[35] *See* Petitions for Reconsideration of Action in Proceedings, Public Notice, Report No. 3176 (June 16, 2021). The Amateur Radio Emergency Data Network (AREDN) submitted a reconsideration petition (filed May 3, 2021), which it subsequently withdrew. *See* Petitions for Reconsideration of Action in Proceedings, Public Notice, Report No. 3176 – CORRECTION (July 7, 2021). 5GAA and AREDN also petitioned the Commission to stay the effective date of the rules set forth in the *First Report and Order*. The rules became effective without Commission action.

[36] Auto Innovators Petition at 1-2.

[37] 5GAA Petition at 2, 7, 11.

[38] *See* Petitions for Reconsideration of Action in Rulemaking Proceeding, 86 FR 35700 (July 7, 2021). See Appendix for the record generated by this Federal Register notice.

[39] *ITS America v. FCC*, 45 F.4th at 411.

[40] *Id.*

rejected each of those arguments and affirmed the Commission's decisions in the *First Report and Order*.[41]

III. DISCUSSION

A. Redesignation of the 5.850-5.895 GHz Band for Unlicensed Use

9. In its Petition for Reconsideration, Auto Innovators asks the Commission to reconsider its decision to redesignate the lower 45 megahertz for unlicensed uses and to restore the lower 45 megahertz block to the ITS service.[42] Auto Innovators contends the Commission exceeded its legal authority in issuing the *First Report and Order* "over the objection of DOT [the Department of Transportation]... , particularly in light of Congress's grant of authority to DOT to administer a nationwide ITS program."[43] Auto Innovators argues in the alternative that the *First Report and Order* merits reconsideration because the DOT and Congressional interests under the Biden Administration continue to express support for maintaining the entire 5.9 GHz band for automotive safety applications, as they did under the previous administration.[44] Auto Innovators also claims that the entire 75 megahertz of the 5.9 GHz band is needed to facilitate the future of transportation (e.g., automated driving, 5G technologies, advanced vehicle-to-everything (V2X) applications).[45]

10. In *ITS America v. FCC*, the D.C. Circuit considered each of these arguments in upholding the Commission's *First Report and Order*. First, the court rejected the arguments that the Commission exceeded its legal authority by repurposing the lower 45 megahertz for unlicensed use. The court recognized that allocating spectrum among competing needs "is a difficult, highly technical task," that "figuring out how much of the spectrum is needed to support a particular activity is exactly what the FCC does," and that "the FCC is entitled to great deference when predicting the likelihood of [future] developments."[46] As the court explained, the Transportation Equity Act "did not transfer away from the FCC its broad authority to manage the spectrum related to [ITS]," but instead "simply required the FCC to account for the [DOT]'s views and the needs of [ITS] when it does so," which is what the Commission did.[47]

11. Second, the court rejected the argument that the change in administration requires the Commission to revisit its decision. Specifically, the court stated that "the Department of Transportation's concerns with the FCC's order are no longer espoused by the Executive Branch" and in fact, "through the Department of Justice, the Executive Branch—which of course includes the Department of

---

[41] *Id.* at 409, 411, 415. The D.C. Circuit also denied AREDN's emergency motion for a judicial stay. *See* Intelligent Transportation Society of America v. FCC, Case No. 21-1130 (consolidated with 21-1131, 21-1141), Order (July 2, 2021).

[42] Auto Innovators Petition.

[43] Auto Innovators Petition at 2. *But see* NCTA Opposition to Petitions at 7-8; Wi-Fi Alliance Opposition to Petitions at 3-6.

[44] Auto Innovators Petition at 2-5. *See also* Auto Innovators Reply at 2-5; IAFC Support Comments to Auto Innovators Petition at 2-4. *But see* NCTA Opposition to Petitions at 4-7; New America's OTI and PK Opposition to Petitions at 16-19; Wi-Fi Alliance Opposition to Petitions at 4; WISPA Opposition to Auto Innovators Petition at 2-4.

[45] Auto Innovators Petition at 6-9. *See also* Auto Innovators Reply at 6-10; 5GAA Comments on Auto Innovators Petition at 2; Lucid Reply to Petitions at 2-3; MEMA Reply to Petitions at 1; T-Mobile Reply to Petitions at 4-5; Continental Reply to Auto Innovators Petition at 5-8. *But see* NCTA Opposition to Petitions at 8-10; New America's OTI and PK Opposition to Petitions at 19-23; Wi-Fi Alliance Opposition to Petitions at 5-6; WISPA Opposition to Auto Innovators Petition at 5-7.

[46] *ITS America v. FCC*, 45 F.4th at 411, 413, 414.

[47] *Id*. at 412.

Transportation—joined the FCC's brief defending the FCC's order."[48] Finally, the court also upheld the Commission's conclusion that retaining the upper 30 megahertz for ITS will be adequate to serve transportation safety needs. It agreed with the Commission that "other [non-5.9 GHz] technologies have alleviated the need for all 75 megahertz of the [5.9 GHz band] to remain dedicated to [ITS]."[49] In addition, the court refused to require the Commission to hold additional spectrum in reserve for "yet-to-arrive technologies" that the Commission found "too uncertain and remote to warrant the further reservation of spectrum."[50] We affirm our decision to repurpose the lower 45 megahertz for the reasons discussed in the *First Report and Order*, including the cost-benefit analysis therein,[51] because nothing in the petition by Auto Innovators persuades us otherwise. Moreover, the D.C. Circuit Court's decision makes clear that the decision to repurpose that spectrum was well within the Commission's authority.

B. Out-of-Band Emissions Limits Permitted in the 5.895-5.925 GHz Band from Unlicensed Operations in the 5.850-5.895 GHz Band

12. In its Petition for Partial Reconsideration, 5GAA asks the Commission to reconsider "the unwanted emission limits permitted from new indoor unlicensed access points and client devices operating in the [lower 45 megahertz]" to better protect ITS operations in the upper 30 megahertz.[52] Specifically, 5GAA asks the Commission to protect ITS operating in the upper 30 megahertz by "afford[ing] C-V2X an additional 20 dB of protection from these [5.850-5.895 GHz] U-NII-4 emissions."[53] 5GAA objects to the Commission's decision to base the OOBE limits for unlicensed devices operating in the 5.850-5.895 GHz (U-NII-4) band on the existing OOBE limits for unlicensed devices in the 5.725-5.850 GHz (U-NII-3) band, as "the technical realities of [5.850-5.895 GHz] U-NII-4 operations necessitate greater protection levels than afforded from [5.725-5.850 GHz] U-NII-3 operations."[54] 5GAA rejects the Commission's assumption of 20 dB building attenuation loss for all indoor access points, contending that "[w]hile many unlicensed access points will experience some building attenuation loss, a 20 dB loss cannot be assumed in every instance."[55] Further, 5GAA claims the Commission's choice of RMS measurement, rather than peak measurement, results in an additional 10-20 dB of unwanted emissions into the C-V2X frequencies.[56] 5GAA concludes that, combined, these decisions permit an unwanted emission limit into the upper 30 megahertz that is 30-40 dB more relaxed

[48] *Id*. at 411.

[49] *Id*. at 413.

[50] *Id*. at 414 (quoting *First Report and Order*, 36 FCC Rcd at 1444, para. 120).

[51] *See First Report and Order*, 35 FCC Rcd at 13490-99, paras. 125-143.

[52] 5GAA Petition at 2.

[53] *Id*.; 5GAA Reply at 2-4. *See also* Auto Innovators Comments at 2-6; FCA Comments in Support at 2-3; Ford Comments in Support at 1-3; Lucid Reply to Petitions at 3-4; MEMA Reply to Petitions at 1-3; Qualcomm Comments in Support at 2-7; Applied Information, Inc. *Ex Parte* at 1; Wyoming Department of Transportation *Ex Parte* at 1; Spoke Safety, LLC *Ex Parte* at 1 (February 28, 2024); Cohda Wireless Pty Ltd *Ex Parte* at 1 (February 29, 2024) (filed under Paul Gray); Jaguar Land Rover *Ex Parte* at 1 (February 29, 2024); The University of Michigan Transportation Research Institute *Ex Parte* at 1 (February 29, 2024); Georgia Department of Transportation *Ex Parte* at 1 (March 4, 2024); Panasonic Corporation of North America *Ex Parte* at 1 (March 11, 2024). *But see* NCTA Opposition to Petitions at 10-25; NCTA Reply at 1-4; New America's OTI and PK Opposition to Petitions at 4-9; Wi-Fi Alliance Opposition to Petitions at 8-11. T-Mobile would prefer the Commission take "a more comprehensive approach to OOBE limits and not finalize the OOBE limits for indoor operations without fully considering outstanding issues raised in both the *Further Notice* and the Petitions." T-Mobile Reply to Petitions at 3.

[54] 5GAA Petition at 3-4.

[55] *Id*. at 4.

[56] *Id*.

than the 5.725-5.850 GHz (U-NII-3) band limit.[57] 5GAA asserts that its suggestion to reduce the allowed 5.850-5.895 GHz (U-NII-4) band OOBE limits by 20 dB "would provide necessary protection for critical safety services" in the upper 30 megahertz, while "still provid[ing] for robust indoor unlicensed operations."[58]

13. 5GAA also contends that the Commission's choice of acceptable 5.850-5.895 GHz (U-NII-4) band OOBE limits based on the existing OOBE limits for unlicensed devices in the 5.725-5.850 GHz (U-NII-3) band is arbitrary and capricious as it fails to satisfy the Administrative Procedure Act (APA)[59] obligation to fully consider the relevant facts underlying its assumptions and articulate a reasoned explanation to support its decision.[60] 5GAA argues that C-V2X will have a "much more robust deployment" than the "thinly deployed" DSRC,[61] while the "heavy use of the [5.850-5.895 GHz] U-NII-4 band will result in longer sustained periods of interference" to the upper 30 megahertz.[62] Therefore, 5GAA claims that the more extensive C-V2X operations warrant greater protections than those provided from 5.725-5.850 GHz (U-NII-3) band operations.[63] 5GAA also contends that the Commission's choice of the RMS measurement standard is arbitrary and capricious because the *First Report and Order* offers "no meaningful analysis of whether C-V2X operations will be able to tolerate the additional unwanted emissions that the RMS measurement approach will permit."[64] 5GAA further states that the Commission does not explain why the RMS measurement technique approved to evaluate the indoor unlicensed operations' OOBE levels "is more suitable for assessing the impact of unwanted emissions on C-V2X services" than the peak measurement approach.[65]

14. In its Petition, 5GAA incorporates by reference a study submitted with its comments on the *FNPRM*, which we refer to as "5GAA's Coexistence Analysis."[66] 5GAA claims this study demonstrates the Commission's OOBE limits adopted in the *First Report and Order* are detrimental to C-V2X, i.e., that the adopted OOBE levels for unlicensed operations "significantly reduce C-V2X's communications range by more than 50% when compared against 5GAA's preferred approach."[67] 5GAA argues that "permitting excessive unwanted emissions could raise concerns about the viability of safety services in the [upper 30 megahertz], delaying or even denying the network effects policymakers and transportation stakeholders hope and expect to achieve."[68]

15. 5GAA's Coexistence Analysis does not convince us to reconsider the OOBE limits decision for indoor unlicensed operations adopted in the *First Report and Order*. First, 5GAA's Coexistence

[57] *Id*. at 4-5.

[58] *Id*. at 2-3.

[59] 5 U.S.C. §§ 551-559.

[60] 5GAA Petition at 8; 5GAA Reply at 7-9. *See also* Auto Innovators Comments in Support at 6-9; Ford Comments in Support at 2; MEMA Reply to Petitions at 3-4; *cf.* MEMA Reply to Petitions at 4-5 (arguing that the Commission failed to provide adequate notice for the adopted OOBE limits). *But see* New America's OTI and PK Opposition to Petitions at 9-15.

[61] 5GAA Petition at 9.

[62] *Id*. at n.28.

[63] *Id*. at 9.

[64] *Id.* at 11.

[65] *Id.*.

[66] *See* 5GAA Petition at 5-6 & n.17 (incorporating by reference 5GAA, Analysis of Coexistence Between [5.850-5.895 GHz] U-NII-4 Devices and C-V2X Under 2020 *5.9 GHz R&O and FNPRM* (June 2021) ("5GAA's Coexistence Analysis"), *attached as* Exhibit C to 5GAA Comments to the *FNPRM* (filed June 2, 2021)).

[67] *See* 5GAA Petition at 5.

[68] *Id*. at 7.

Analysis assumes an average activity factor (also known as duty cycle) of 2 percent for the percentage of time when an individual indoor unlicensed device is transmitting in the lower 45 megahertz, i.e., adjacent to the lower edge of the upper 30 megahertz.[69] In contrast, in the *6 GHz First Report and Order* (expanding unlicensed operations in 6 GHz U-NII bands, i.e., adjacent to the upper edge of the upper 30 megahertz), the Commission assessed the potential for Low Power Indoor unlicensed devices operating in the 6 GHz U-NII bands to cause harmful interference and determined that the appropriate activity factor per unlicensed device is only 0.4%.[70] That activity factor was based on measurement data for 5 GHz U-NII routers.[71] Therefore, unlicensed 5.850-5.895 GHz (U-NII-4) band devices operating in the lower 45 megahertz can be assumed to operate with that same activity factor in determining 5.850-5.895 GHz (U-NII-4) devices' potential to cause harmful interference to ITS operations in the upper 30 megahertz. Thus, 5GAA's assumption leads to approximately 7 dB over-estimation in the average duty cycle power per unlicensed device's transmissions over time.[72]

16. Second, 5GAA's Coexistence Analysis uses a relatively low 20 dBm (100 mW) on-board unit (OBU) transmit power,[73] where under our current rules, it could have used a higher OBU transmit power limit as currently permitted in the section 95.3189 OBU technical standards.[74] Section 95.3189 currently requires compliance with the Institute of Electrical and Electronics Engineers (IEEE) 802.11p-2010 standard: Amendment 6: Wireless Access in Vehicular Environments.[75] Under the IEEE standard, OBUs operated by entities other than state and local governments are allowed up to 33 dBm EIRP, i.e., 20 times as strong as 5GAA used in the Coexistence Study.[76] By using 20 dBm in its analysis, 5GAA artificially sets the OBU EIRP at a level that significantly increases the potential for 5.850-5.895 GHz (U-NII-4) band OOBE to cause harmful interference to ITS operations in the upper 30 megahertz.[77]

---

[69] *See* 5GAA's Coexistence Analysis at 18.

[70] *See Unlicensed Use of the 6 GHz Band, Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz*, ET Docket No. 18-295, Report and Order and Further Notice of Proposed Rulemaking, 35 FCC Rcd 3852, 3889, para. 101 (2020) (*6 GHz Order*). In recently adopted rules for a new class of unlicensed devices in the 6 GHz band (5.925-7.125 GHz) called very low power (VLP) devices, the Commission relied on two computer simulations conducted by proponents of VLP devices that assumed activity factors of 2% and 1.5%. *Unlicensed Use of the 6 GHz Band, Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz*, ET Docket No. 18-295, Second Report and Order, Second Further Notice of Proposed Rulemaking, and Memorandum Opinion and Order, FCC 23-86 at paras. 35-36 (adopted Oct. 19, 2023) (citing Apple Inc., Broadcom Inc. *et al.* Feb. 28, 2023 *Ex Parte*, ET Docket No. 18-295, at 9; Apple Inc. Sept. 14, 2023 *Ex Parte*, ET Docket No. 18-295, at 7). These activity factors were assumptions for a class of unlicensed devices that are not yet available. The 0.4% activity factor the Commission found appropriate in the *6 GHz Order* was based on measured data from 500,000 Wi-Fi access points. *See 6 GHz Order*, 35 FCC Rcd at 3894, para. 117.

[71] *Ex Parte* of CableLabs in ET Docket No. 18-295 at 1 and attached Coexistence Study at 5 (Dec. 20, 2019).

[72] *See also* NCTA Opposition to Petitions at 21-22. For reference, a 3 dB increase in power is twice as much power, a 6 dB increase is 4 times as much power, and so on, where the power is doubled for every 3 dB increase.

[73] *See* 5GAA's Coexistence Analysis at 20.

[74] *See* 47 CFR § 95.3189.

[75] *See* 802.11p-2010, IEEE Standard for Information technology – Local and metropolitan area networks – Specific requirements – Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 6: Wireless Access in Vehicular Environments (2010).

[76] *See id*. at 31, Table I.5a.

[77] Recently, the Commission granted waivers to parties requesting to deploy C-V2X operations in the upper 30 megahertz prior to the adoption of final rules, permitting OBUs to operate with an EIRP of 33 dBm. *See Request for Waiver of 5.9 GHz Band Rules to Permit Initial Deployment of Cellular Vehicle-to-Everything Technology*, ET Docket No. 19-138, Order, DA 23-343 (rel. April 24, 2023); *Request to Modify April 24, 2023 Waiver Order of the 5.9 GHz Band Rules to Permit Initial Deployment of Cellular Vehicle-to-Everything Technology*, ET Docket No. 19-
(continued….)

17. 5GAA's claims that while "there may be 20 dB [of building] attenuation in some cases, [] there exist other situations where very little attenuation would lead to harmful interference to C-V2X operations" do not persuade us to reconsider the OOBE limits adopted in the *First Report and Order*.[78] 5GAA concedes that 20 dB of building attenuation as compared to the 5.725-5.850 GHz (U-NII-3) OOBE limits is appropriate "in some cases." 5GAA does not take into account other factors the Commission considered that would accommodate cases with less building attenuation, such as the path loss due to the separation distance between indoor unlicensed devices and C-V2X receivers.[79] 5GAA's Coexistence Analysis also fails to adequately consider the reduction in antenna gain caused by the directionality of C-V2X receiving antennas. 5GAA assumes the randomness of peaks and nulls in the real antenna gain patterns of both unlicensed devices and C-V2X devices to have a zero dB average.[80] However, C-V2X antennas are typically horizontal in nature in front of and behind vehicles and positioned to maximize coverage along road surfaces. This orientation generally will provide some measure of isolation between unlicensed devices' transmissions and OBU receivers and help reduce unlicensed devices' OOBE levels received by a C-V2X device in the upper 30 megahertz. Because the antenna patterns and coverage requirements differ between unlicensed and C-V2X operations, the assumption of a zero dB average gain is incorrect. C-V2X transmissions received by an OBU from other OBUs is more likely to occur in or near the main lobe of the OBU receiving antenna, which will result in a higher average gain for the reception of C-V2X transmissions than the zero dB average assumed in 5GAA's Coexistence Analysis. In sum, building attenuation, coupled with attenuation due to path loss and the C-V2X OBU receiving antenna angular discrimination, sufficiently support the Commission's decision that its adopted 5.850-5.895 GHz (U-NII-4) band OOBE limits that fall in the upper 30 megahertz will not cause harmful interference to C-V2X operations.

18. 5GAA notes that in 2016, the Commission adopted relaxed OOBE limits for 5.725-5.850 GHz (U-NII-3) band (which form the basis of the 5.850-5.895 GHz (U-NII-4) band OOBE limits adopted in the *First Report and Order*) to accommodate unlicensed fixed point-to-point antennas in that band; since 5.850-5.895 GHz (U-NII-4) indoor unlicensed access points do not use such antennas, the Commission should not have established even more relaxed 5.850-5.895 GHz (U-NII-4) band OOBE limits than those for 5.725-5.850 GHz (U-NII-3).[81] However, in 2016, the Commission chose to provide "a single, consistent OOBE requirement for all equipment" that operates in the 5.725-5.850 GHz (U-NII-3) band rather than "apply different OOBE requirements based on a variety of situations."[82] As such, 5GAA's distinction between types of unlicensed equipment in this case is inapplicable and thus, the Commission's decision to base OOBE limits for the 5.850-5.895 GHz (U-NII-4) band equipment on the OOBE limits for the 5.725-5.850 GHz (U-NII-3) band was appropriate.

19. We disagree with 5GAA's assertion that RMS measurement of unlicensed devices' OOBE power, as opposed to peak measurement, permits more power from these OOBE in the adjacent band, resulting in the receipt of an additional 10-20 dB of unwanted OOBE on the C-V2X frequencies in the upper 30 megahertz.[83] Measurements of infrequent worst-case peak OOBE of short duration are not an

138, DA 23-586 (rel. July 5, 2023); *Requests for Waiver of 5.9 GHz Band Rules to Permit Initial Deployment of Cellular Vehicle-to-Everything Technology*, ET Docket No. 19-138, Letter (rel. Aug. 16, 2023).

[78] *See*, *e.g.*, Letter from 5GAA to Marlene H. Dortch, Secretary, FCC, ET Docket No. 19-138, at 2 (filed Dec. 18, 2023) (5GAA Dec. 18, 2023 *Ex Parte*).

[79] *First Report and Order*, 35 FCC Rcd at 13475-76, para. 83.

[80] *See* 5GAA's Coexistence Analysis at 11.

[81] *See*, *e.g.*, 5GAA Dec. 18, 2023 *Ex Parte* at 1-2 (citing *U-NII 5 GHz MO&O*, 31 FCC Rcd at 2322, para. 15).

[82] *U-NII 5 GHz MO&O*, 31 FCC Rcd at 2322, para. 15.

[83] *See* 5GAA Petition at 10-11.

accurate or realistic assessment of the potential for a device to cause harmful interference.[84] As the Commission explained in the *First Report and Order*, instances of peak OOBE power in an unlicensed device's transmitted signal only occur occasionally and are of limited duration; RMS measurement of OOBE will provide a more accurate assessment of an unlicensed device's potential to cause harmful interference because RMS measurements represent the continuous power being generated from a device.[85]

20. We also disagree with 5GAA's assertion that the Commission "traditionally" uses a peak measurement for assessing 5 GHz U-NII OOBE.[86] As a general rule, we establish OOBE measurement procedures based on the technical and operational characteristics of the equipment operating in the specific band under consideration and the design characteristics of equipment used in adjacent-bands.[87] Peak measurements may be required when the Commission determines that peak emissions would have significant interference effects, as was the case for compliance testing of 5.725-5.850 GHz (U-NII-3) band devices' unwanted emissions to protect federal terminal Doppler weather radars in the 5.470-5.725 GHz (denoted as U-NII-2C) band.[88] In contrast, in the *6 GHz Order*, the Commission adopted OOBE levels based on RMS measurement (as well as other appropriate techniques for measuring average power) to protect ITS operations in the 5.9 GHz band from the OOBE of unlicensed operations in the adjacent 5.925-6.425 GHz (denoted as U-NII-5) band.[89] Compliance testing of 5.850-5.895 GHz (U-NII-4) band devices' unwanted emissions to protect ITS operations above the 5.850-5.895 GHz (U-NII-4) band is comparable to compliance testing of 5.925-6.425 GHz (U-NII-5) band devices' unwanted emissions to protect ITS operations below the 5.925-6.425 GHz (U-NII-5) band, and thus, RMS detection is appropriate in the case of measuring 5.850-5.895 GHz (U-NII-4) band OOBE levels.[90] Moreover, allowing the flexible RMS measurement technique will help promote shared spectrum technologies and drive greater productivity and efficiency in spectrum usage.[91]

21. Accounting for the above-noted weaknesses in 5GAA's Coexistence Analysis, as well as considering the restriction on unlicensed use of the lower 45 megahertz to indoor locations and the requirement for RMS measurements for analyzing the potential impact of the adopted unlicensed device OOBE limits, we conclude that the indoor unlicensed device OOBE limits the Commission adopted in the *First Report and Order* will sufficiently protect C-V2X communications in the upper 30 megahertz from

[84] *See*, *e.g.*, Amendment *of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, GN Docket No. 12-354, Order on Reconsideration and Second Report and Order, 31 FCC Rcd 5011, 5040, para. 105 (2016) (*3.5 GHz Order on Recon*). This approach is inconsistent with the Commission's "oft-stated rejection of worst case approaches to measurements and interference protection analysis." *Id.*

[85] *See First Report and Order*, 35 FCC Rcd at 13476, para. 85. *See also* Wi-Fi Alliance Opposition to Petitions at 11.

[86] 5GAA Petition at 10.

[87] Indeed, in some cases, the Commission has concluded that emission power measurements may be performed using either RMS-detection or peak-detection. *See 3.5 GHz Order on Recon*, 31 FCC Rcd at 5039, para. 103.

[88] The Commission's Office of Engineering and Technology's Laboratory Division specified a peak measurement guideline for compliance testing of 5.725-5.850 GHz (U-NII-3) band devices' unwanted emissions, *see* KDB Publication No. 789033, available at https://apps.fcc.gov/oetcf/kdb/ (query on publication No. 789033), to mitigate a known interference issue with the federal radars in the 5.470-5.725 GHz (U-NII-2C) band that are not present in the 5.9 GHz band. *See First Report and Order*, 35 FCC Rcd at 13477, para. 85. *See also 6 GHz Order*, 35 FCC Rcd at 3926, para. 198; Wi-Fi Alliance Opposition to Petitions at 11.

[89] *See 6 GHz Order*, 35 FCC Rcd at 3926, para. 198

[90] *See First Report and Order*, 35 FCC Rcd at 13476, para. 85.

[91] *See also 3.5 GHz Order on Recon*, 31 FCC Rcd at 5041, para. 108 (a comparable analysis of the interference potential, in this case, between and among Citizens Broadband Radio Service users and incumbent users).

harmful interference. Consequently, we would not expect that C-V2X operations will experience reduced communications range from unlicensed OOBE falling within the ITS band.[92]

22. In response to 5GAA's claim that the Commission's choices of acceptable OOBE limits and RMS measurement of OOBE levels are arbitrary and capricious,[93] we note that in *ITS America v. FCC*, the U.S. Court of Appeals for the District of Columbia Circuit determined that the Commission was not acting arbitrarily and capriciously when it implemented "restrictions on unlicensed devices using the lower 45 megahertz—such as emissions limits and indoor-use-only rules—to keep those devices from interfering with intelligent transportation systems in the upper 30 megahertz."[94] The court reiterated its inclination to "uphold the Commission if it makes a technical judgment that is supported with even a modicum of reasoned analysis, absent highly persuasive evidence to the contrary."[95] The Commission has explained in detail its technical judgment that the adopted restrictions will minimize the potential for harmful interference to the extent appropriate in this context and 5GAA has not provided highly persuasive evidence to refute the Commission's judgment.[96] 5GAA's argument that the Commission was arbitrary and capricious by not increasing OOBE protections of C-V2X in anticipation of possible heavier uses of both the lower 45 megahertz by unlicensed operations and the upper 30 megahertz via C-V2X deployment is speculative and similarly fails. Therefore, we reject 5GAA's claim that the Commission's decisions regarding protecting ITS operations in the upper 30 megahertz from unlicensed devices' OOBE are arbitrary and capricious, and we decline to reconsider the indoor unlicensed device OOBE limits adopted in the *First Report and Order*.

IV. PROCEDURAL MATTERS

23. *Paperwork Reduction Act Analysis*. This Order on Reconsideration does not contain any new or modified information collection requirements subject to the Paperwork Reduction Act of 1995, Public Law 104-13. Thus, it does not contain any new or modified information collection burden for small business concerns with fewer than 25 employees, pursuant to the Small Business Paperwork Relief Act of 2002, Public Law 107-198, see 44 U.S.C. § 3506(c)(4).

24. *Congressional Review Act*. The Commission will not send a copy of this Order on Reconsideration to Congress and the Government Accountability Office pursuant to the Congressional Review Act, see 5 U.S.C. § 801(a)(1)(A), because no rule was adopted or amended.

25. *Regulatory Flexibility Act Analysis*. In this present Order on Reconsideration, the Commission promulgates no additional final rules. Our present action is, therefore, not an RFA matter.

[92] As a reminder, under part 15 of the Commission's rules, unlicensed devices operate on the condition of not causing harmful interference to authorized stations. 47 CFR § 15.5(b)-(c). *See also* NCTA Opposition to Petitions at 14-15.

[93] *See* 5GAA Petition at 8-11.

[94] *ITS America v. FCC*, 45 F.4th at 415.

[95] *Id*. (citing *Mobile Relay Associates v. FCC*, 457 F.3d 1, 8 (D.C. Cir. 2006)).

[96] *First Report and Order*, 35 FCC Rcd at 13474-77, paras. 80-86.

V. ORDERING CLAUSES

26. Accordingly, IT IS ORDERED that pursuant to Section 1.429 of the Commission's rules, 47 CFR § 1.429, the Petition for Reconsideration filed on June 2, 2021 by Auto Innovators and the Petition for Partial Reconsideration filed on June 2, 2021 by 5GAA ARE DENIED.

Federal Communications Commission

Marlene H. Dortch
Secretary

Appendix

Record on the Auto Innovators Petition

5GAA Comments
Wireless Internet Service Providers Association (WISPA) Opposition
Continental Automotive Systems Reply in Support
International Association of Fire Chiefs (IAFC) Support Comments
Auto Innovators Reply

Record on the 5GAA Petition

Auto Innovators Comments in Support
FCA US LLC Comments in Support
Ford Motor Company Comments in Support
Qualcomm Comments in Support
NCTA Reply (to Qualcomm's Comments)
Qualcomm Response to NCTA

Record on Both Petitions

Oppositions

NCTA—The Internet & Television Association (NCTA) Opposition
New America's Open Technology Institute and Public Knowledge (New America's OTI and PK) Opposition
Wi-Fi Alliance Opposition

Replies

5GAA Reply
Lucid Group Reply
Motor & Equipment Manufacturers Association (MEMA) Reply
T-Mobile Reply

Ex Parte Comments

NCTA (Sept. 16, 2021)
Auto Innovators (June 1, 2022)
5GAA (Dec. 6, 2023; Dec. 18, 2023 (3); Feb. 2, 2024; Feb. 9, 2024; Feb 13, 2024; Feb 22, 2024)
Applied Information Inc. (February 27, 2024)
The Wyoming Department of Transportation (February 27, 2024)
Spoke Safety, LLC (February 28, 2024)
Cohda Wireless Pty Ltd (February 29, 2024) (filed under Paul Gray)
Jaguar Land Rover (February 29, 2024)
The University of Michigan Transportation Research Institute (February 29, 2024)
Georgia Department of Transportation (March 4, 2024)
Panasonic Corporation of North America (March 11, 2024)